

The National Academies of Sciences, Engineering, and Medicine

Committee on Astrobiology and Planetary Science

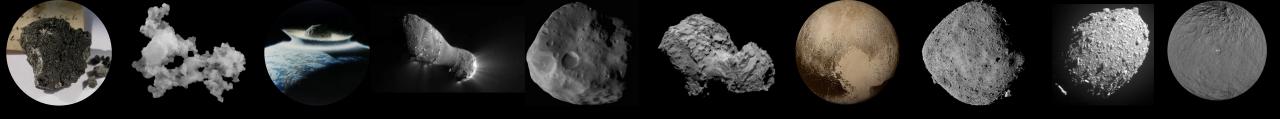
Meeting No. 3 on New Frontiers Mission List Review

Small Bodies Assessment Group (SBAG)

Report on Relevant Scientific and Technological Advances

Lori Feaga (SBAG Chair)

20 May 2024



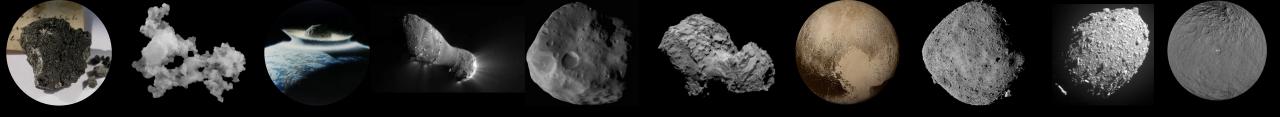
New Frontiers 5 & 6 Mission Themes with SBAG Relevance

- Comet Surface Sample Return (CSSR)
 - NF-1-6 lists; long-standing top priority
- Centaur Orbiter and Lander (CORAL)
 - NF-6 list; indicating compelling science
- Ceres Sample Return
 - NF-6 list; indicating compelling science



Method of Collecting Community Input

- Briefed Steering Committee (SC) first and offered 2-week response period
 - SC has representation from various institutions and science expertise
- Sent e-mail to the SBAG listserve announcing 2 open community chat opportunities and direct e-mail response options
- Community took advantage of all opportunities
 - SC feedback, direct e-mails, office visits, community chat participation



Summary

- Origins, Worlds, and Life (OWL 2023-2032 Decadal) recommended all three of the small bodies mission concepts (listed on slide 2: CSSR, CORAL, Ceres Sample Return) because they are unique from each other and provide distinct high-priority science for the decade
- Some scientific advancements have been made since the preparation of *Origins, Worlds,* and Life (OWL 2023-2032 Decadal) related to each theme
- It is clear that sample return and in situ analyses play a central role in providing breakthrough science and ground-truth constraints
- Community input only strengthened that all 3 small bodies mission themes on the combined NF-5 & 6 lists remain priorities for advancing the science of small bodies and planetary formation
- Current technological studies and advancements may provide operational and cost savings and risk reduction for future small bodies missions
- Continued delays to both the Discovery and New Frontiers programs greatly affect the opportunities to study small bodies, so an AO with all opportunities this decade is important
- The community supports combining the NF-5 & 6 lists for the next AO with respect to the small bodies mission themes



Scientific advancements – comet sample return

• Sample analyses from Ryugu and Bennu highlight the value of sample return and provide a carbonaceous asteroid baseline to compare to

• Carbonaceous regolith composition and mineralogy of Bennu indicate substantial aqueous alteration and includes phosphate salts (Lauretta et al.

2024, submitted)

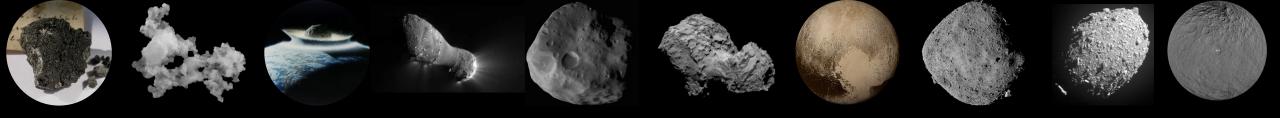
 Primordial grain alignment preserved in the leas primitive IDPs (magnetite studies, Hu & Winarski 2021)

 Organics were never brought back from a come Stardust collection – but would be requirement

 Need a sample from a primitive population, wit alteration, least modified organics, and preserv probe material from the molecular cloud and up planetesimal growth

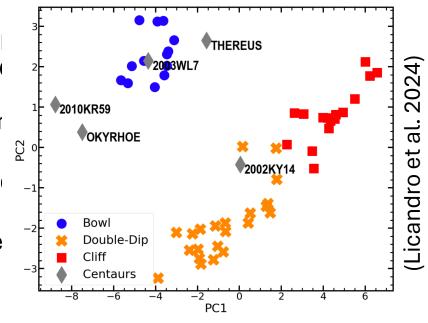


(Lauretta et al. 20



Scientific advancements - Centaurs

- Centaurs are exciting because they're thought to be a transitional population between trans-Neptunian objects and Jupiter-family comets
 - JWST studies show 3 distinct compositional classifications among TNOs observed and Centaurs echo findings (DiSCo-TNO project; Pinilla-Alonso et al. 2021, 2023; Licandro et al. submitted)
- Chiron, a Centaur studied at 18 au with JWST, has primore readily observed in the coma and not on the surfactory are trapped in ices (e.g., CO₂) detected on the surfactory Alonso, private comm.)
 - Study of a Centaur's primordial composition would give par related to the Solar System's formation
- Very recent work has improved understanding of the
 - Discovering more ring systems
 - Rings likely have small shepherd moons or nearby perturbe
 - Additional investigations are enabled by an orbiter/lander





Scientific advancements - Ceres

 Recent lab studies have shown that bodies harboring a briny ocean would encapsulate organics in the salt crystals accessible on the surface

• Discovery of new ammonium salts (De Sanctis et al. 2024) and chlorides in

many sités (Bramble and Hand 2022) in Dawn data

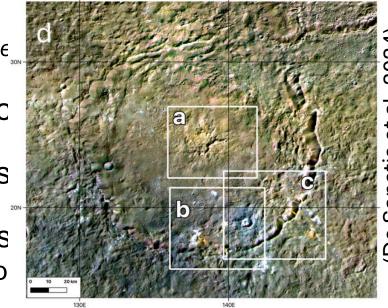
• Salts detected in returned Bennu fines (Timms ϵ_{∞} (Barnes et al. 2024)

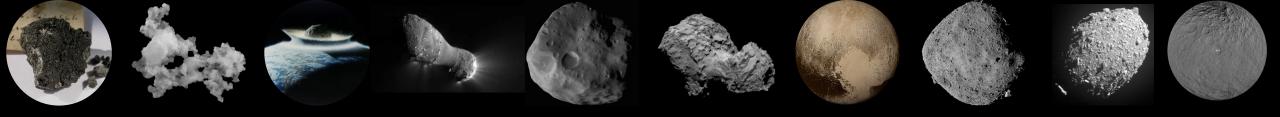
• Ceres' interior could be dominated by organic (Reynard & Sotin 2023)

• Organic matter found in new locations across (Nathues et al. 2023)

Need to improve upon in situ studies of Ceres

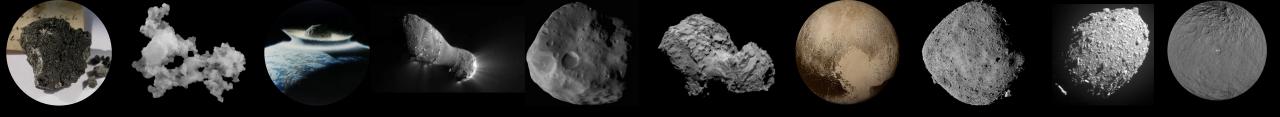
• Sample return impactful to enable the organics to





Technological Advances

- Sample collection & curation lessons learned from Bennu
- Autonomous Navigation Demonstration Relevance Assessment Team (ANDRAT)
 - 6-month NASA chartered study to present report in summer
 - Assessing risks and benefits of utilizing various levels of autonomous navigation in mission design and tech demonstrations to retire risks relevant to planetary science
 - Potential for new developments in autonomous navigation to:
 - Decrease operational costs, ground operations, and reliance on over-subscribed DSN for deep space missions
 - Increase ability for more accurate landing/sampling ellipses on small bodies and science return



Additional thoughts

- Ground and space-based assets are critical in offering supporting studies to reduce mission risk and narrow scientific gaps, but in situ studies and sample return are the ultimate goal and provide ground truths not otherwise attainable
- International collaboration, especially in sharing and analyzing returned samples, are essential in ensuring diverse expert teams and cutting-edge curation and analytical capabilities to maximize the science



Community raised question for CAPS

- Is there a cost to the community for combining the lists/taking the NF-6 list?
 - Additional delay in release of an AO?
 - Logistical issues that have not been relayed to the community?



Summary

- Origins, Worlds, and Life (OWL 2023-2032 Decadal)
 recommended that all three of the small bodies mission concepts
 (listed on slide 2: CSSR, CORAL, Ceres Sample Return) were unique
 from each other and provided distinct high-priority science for the
 decade
- Scientific motivation has not changed since the preparation of OWL
- Sample return and in situ analyses of diverse primitive populations remains a priority for the small bodies community
- The community strongly supports the all-encompassing NF-6 list for the next AO with respect to the small bodies mission themes